FINAL REPORT

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RURAL WATER QUALITY PROJECT

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Prepared by: Prairie Farm Rehabilitation Administration

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RURAL WATER QUALITY PROGRAM
Project #97-159
File: 6672-1-12-1
PROJECT REPORT

APRIL 2002

Summary:

The Rural Water Quality Program represents $5 million of water quality research. The research investigated ways to protect water supplies, and enhance water quality for the needs of Canada's Agri-Food Sector. The Canada-Saskatchewan Agri-Food Innovation Fund contributed $2.35 million. Other contributions included $400,000 from Agriculture and Agri-Food Canada's (AAFC's) Rural Water Development Program, administered by the Prairie Farm Rehabilitation Administration (PFRA), and, cash and major in-kind contributions from a variety of private industry, individual producers and producer associations, AAFC's Research Branch, Environment Canada, and Universities of Saskatchewan, Regina, Manitoba and Alberta.

The Rural Water Quality Program was a broad-reaching initiative designed to increase the Agri-Food Sector's understanding of:

1. *Protecting surface and ground water supplies from potential agricultural impacts,*
2. *Enhancing farm water sources, and,*
3. *Treating water for small-scale Agri-Food Sector uses (including rural domestic needs).*

Effective, economic methods of water source protection and enhancement were researched. Appropriate water treatment processes were studied and adapted to farm-scale needs. Findings were transferred to the sector in a well-planned technology transfer program designed in unison with the research studies. Knowledge gained from AFIF's Rural Water Quality Program will benefit Canada's Agri-Food Sector and rural Canadians who chose to adopt appropriate technologies for rural water quality issues. Agriculture depends on good quality water and requires sound advice for water protection and treatment. There is a need to continue to transfer what was learned after termination of the Agri-Food Innovation Fund program. The end result will be better environmental protection from farming practices, improved farm products and economics, and a better quality of life for rural Canadians.

File 6672-1-12-1-1

PROJECT #97-159
Projects 250618, 250619, 250620, 250621, 250622, 250623, 250624, 250625. 250626, 250627

PART 1: RURAL WATER QUALITY SURVEY (Project 250618; File: 6672-1-12-1-1)

PURPOSE:

- obtain an understanding of the nature and extent of rural water quality issues to ensure that work undertaken with AFIF support focuses on those aspects which represent the greatest impediment to rural development
- survey the agri-food sector and producers to obtain an understanding of their knowledge and approaches in dealing with water quality problems facing their sector
- undertake a literature review to determine what water quality requirements exist for the agri-food sector

DETAILS:

- Prairie Research Associates survey of the Agri-Food Sector and Producers is documented in the published **Rural Water Quality Survey** report.
- **Water Quality Requirements for Saskatchewan's Agri-Food Sector** publication documents the water quality needs for a variety of agri-food sector components (see list of Fact Sheets below).

KEY FINDINGS:

- Many rural people and the agri-food sector do not know "what they do not know" about the effect of water quality on agricultural production and the quality of life.
- Experts believe problems exist, better education and awareness is necessary, and improved technologies are required to protect water supplies, enhance management of the source water, and adopt suitable technologies for rural water treatment.
- In light of Walkerton and North Battleford water inquiries, the Canadian public are concerned about water quality. This is becoming more and more evident at the types of questions being posed and requests for advice from people at workshops held to increase the understanding of water quality and its relationship to the agri-food sector.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Highlights of Agri-Food Sector survey were presented to industry, public and government staff at a variety of meetings and workshops.
- The publication, "Water Quality Requirements for Saskatchewan's Agri-Food Sector is being modified to enable posting on the Internet.
- The accompanying fact sheets, listed below, are now posted on the Internet for widespread access (www.agr.ca/pfra/water/wqualite):
  - ***Livestock and Water Quality***
  - ***Irrigation and Salinity***
  - ***Field Irrigation and Water Quality***
  - ***Water Quality and Micro-Irrigation for Horticulture***
  - ***Farm Chemical Spraying and Mixing Water Quality***
  - ***Agricultural Industry and Water Quality***
  - ***Domestic Water Quality***

COLLABORATORS & OTHER CONTRIBUTIONS:

- Prairie Research Associates
- Water Research Corp.
- Industry representatives
- In-kind contributions from AAFC-PFRA
- In-kind and External contributions total approximately $50,000

PART 2: WATER QUALITY TREATMENT AND ENHANCEMENT

2.1 BIOLOGICAL TREATMENT SYSTEM (Project 250619; File:6672-1-12-1-2)

PURPOSE:

- pilot test two commercially available, low maintenance biological treatment systems which can be applied in the following rural uses: livestock, food and non-food processing, household

DETAILS:

Published reports document the application of biological treatment:

- **Biological Filtration - A Literature Review**
- **Biological Filtration - A Performance Analysis - Volume 1**
- **Biological Filtration - A Performance Analysis - Volume 2**
- **Development of Biological Pre-Filters for the Treatment of Eutrophic Water Supplies**

KEY FINDINGS:

- Biological water filtration is ideal for small-scale rural water treatment needs.
- Biological treatment is suited to some surface water problems (organic matter, colour, etc), and ground water problems (iron, arsenic)
- Biological water treatment is an economical way to deal with difficult-to-treat water quality problems common on prairie water supplies.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Two articles on biological treatment were publ ished in Prairie Water News (hard copies were distributed across the prairies; the information is also posted on the Internet at: www.quantumlynx.com):
  - ***Why won't my carbon filter work?***
  - ***Biological treatment shows promise***
- Re-printed fact sheets in lots of 5,000 for extension and trade show distribution:
  - ***Biological Treatment of Ground Water***
  - ***Biological Treatment of Surface Water***
  - ***Slow Sand Filters***
- Published papers:
  - **Biological Filtration for Treatment of Prairie Surface Water and Ground Water Sources** in 9th National Conference on Drinking Water - Maintaining Drinking Water Quality - Lessons from the Prairies and Beyond, May 16-18, 2000, Regina
  - **Biological Water Treatment for Small Systems** in the Third NSF International Symposium and Technology Expo on Small Drinking Water and Wastewater Systems: Treatment, Management and Finance, April 22-25, 2001, Washington

- Developed a Macromedia Flash presentation on ***Filtration***, depicting and comparing how sand filters, carbon filters, gravity slow sand filters, and biological granular activated carbon filters function. This is presently used as a teaching tool in workshops, and will posted on the Internet.
- Developed a Macromedia Flash presentation on ***Disinfection***, depicting how disinfection may be used to kill disease-causing organisms, and emphasising that disinfection must occur after pre-treatment with coagulation and filtration. The material is used in workshops and will be posted on the Internet.
- Developed a Macromedia Flash presentation entitled, ***From Source to Tap***, showing how BMPs, Aeration, Coagulation, Filtration, Disinfection and Polishing Treatment (membranes or distillers) can be used to improve rural water quality.
- Highlighted the applicability of biological water treatment at numerous workshops, field days and trade shows.
- Retrofitted a Surface Water Treatment Trailer for field day tours across Saskatchewan in Scott, Melfort, Rosthern, Vanguard, Indian Head
- Developed recommendations for biological water treatment for publication in **Quality Farm Dugouts**, a federal-provincial manual on how to build, operate and maintain farm dugouts (ponds).

COLLABORATORS AND OTHER CONTRIBUTIONS:

- Ten rural producers involved in pilot testing and field trials
- WateResearch Corp.
- Alberta Research Council
- Mainstream BMS Ltd.
- Davnor - Canadian Water Filter
- In-kind contributions from AAFC-PFRA
- In-kind and External Contributions total over $100,000.

2.2 MEMBRANES (Project 250620; File: 6672-1-12-1-3)

PURPOSE:

- pilot test membrane systems for the agri-food industry and improve the understanding of where membrane treatment systems are applicable to rural situations (e.g. processing, livestock watering, greenhouse irrigation, rural water pipelines, domestic)

DETAILS:

- Evaluated a variety of membrane systems for agri-food sector applications
- reverse osmosis at a commercial rabbit/sheep farm
- reverse osmosis at a dairy farm
- nanofiltration at a rural water utility
- microfiltration at a rural water utility serving 90 farms
- Evaluated pre-treatment needs and requirements using a variety of technologies (sand filters, coagulation and sand filters, bag and depth cartridge pre-filters, integrated membrane systems, etc.)
- Conducted ground water evaluations and characterizations (as a means of understanding common ground water problems and treatment issues)
- Worked in partnership with rural water utilities to understand water quality issues in rural utilities and associated treatment needs
- Reports include:
- **Membrane Literature Review for the Agri-Food Sector of the Canadian Prairies**
- **Nanofiltration Performance Evaluation**
- **Coagulation Pre-treatment for Rural Membrane Applications**
- **RM of Mount Hope Water Well Inventory and Microbiological Assessment**
- **Groundwater Characterization in the RM of Leroy**

KEY FINDINGS:

- Membrane applications are on the increase, for small rural industrial applications as well as small utilities and individual domestic needs. These applications may benefit from knowledge gained from some of the pre-treatment research studies. For example, long-term use of membranes requires effective pre-treatment and membrane operation to minimize membrane fouling and plugging.
- Disposal of membrane concentrate is a design issue and will require environmental permitting for larger systems or systems discharging to the environment

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Presented at numerous field days, workshops, industry trade shows. Advised on the suitability of membrane applications for rural agri-food sector use.
- Used the Ground Water Trailer as a demonstration tool at field day tours such as the Shelterbelt Centre's Field Day at Indian Head.
- Used smaller models at other trade shows such as Agribition, Farm Progress Show, etc.

- Developed a Macromedia Flash presentation depicting how reverse osmosis membranes work, to be used in displays, trade shows, workshops, etc. It is posted on the Internet: www.agr.gc.ca/pfra/water/flash/en/revosmoe.htm

COLLABORATORS AND OTHER CONTRIBUTIONS:

- RM of Mount Leroy
- RM of Mount Hope
- Cutbank Rural Water Utility
- Saskatchewan Association of Rural Water Pipelines
- Canadian Adaptation and Rural Development Saskatchewan (CARDS) program
- AAFC-PFRA's Rural Water Development Program
- In-kind and External Contributions total over $500,000

2.3 COAGULATION (Project 250621; File: 6672-1-12-1-4)

PURPOSE:

- optimize dosage and design guidelines for coagulation of dugouts and coagulation treatment cells to enhance water quality supplies for livestock, crop spraying, processing and drinking
- evaluate the performance of a small scale coagulation system that could be utilized for rural application (small-scale industrial demand, in-house demands, etc.)
- evaluate the ability of raw and treated surface water as a mix water for chemical spraying efficacy as an alternative to improving poor source water characteristics
- evaluate other applications of where small-scale coagulation systems/infrastructure may assist the agri-food sector

DETAILS:

- Coagulation findings are detailed in the reports:
- **Cattle Weight Gain Study and coagulation pre-treatment**
- **Hog Weight Gain Study and coagulation pre-treatment**
- **Coagulation Pre-screening of Manitoba Dugouts Affected by the 1997 Red River Flood for use of coagulation to reclaim flood-affected dugouts**
- **Elite Coagulation Project, Multi-Pork Site (Hog Production)**
- **Water Quality and Herbicide Efficacy**
- **Algae Effects on Coagulation**
- **Cyanobacterial Ecology and Toxicity in Eutrophic Waters of Western Canada**
- **Coagulation of a Difficult to Treat Source Water**
- **Improving Cold Water Coagulation with Polymers and Coagulant Aids**
- **Beaker Test**
- **Mixing**
- **Coagulation Cells**
- **Coagulation Cell Liner Modification**
- **Unlined Coagulation Cells**
- **Performance Monitoring of the Floc System 100**
- **Peer Review of Coagulation Research for adopting coagulation as a water treatment technique for the Agriculture Sector**
- **Sulphate Removal from Water**

KEY FINDINGS:

- Coagulation Cells
- Coagulation water treatment is applicable to the agri-food sector using lined coagulation cells
- Water quality is maintained throughout summer and winter
- Proper chemical dosages is essential for successful treatment
- RPE liners are prone to failure after several years of use

- Coagulation in a coagulation cell removes on average, 80% colour, 60 % DOC, 50% turbidity, 90% chlorophyll *a* and 90% phosphorus.

- Mixing
- Coagulation requires adequate mixing for good results
- Boat motor propellor and air are efficient mixing mechanisms
- Water jets are inefficient at mixing
- Poor mixing will increase the post-coagulation turbidity level but does not significantly affect the colour, DOC, chlorophyll *a* and phosphorus removal

- Algae Effects on Coagulation
- Presence of algae affects coagulation results
- Pre-treatment with copper sulphate improves coagulation results
- Ferric chloride alone can achieve removal of algae
- Beneficial zooplankton population was drastically reduced with coagulation treatment using a pH level less than 6.0
- Hepatotoxic microcystins are the most prevalent toxin
- The colorimetric protein phosphatase inhibition assay method is the best method for detecting cyanobacteria toxins

- Beaker Test
- The beaker test is a simple, accurate and inexpensive method of coagulant dose determination
- The most consistent results are achieved by a rapid mix of 180 rpm for 10 seconds following initial chemical addition and 30 rpm for 10 seconds following incremental chemical addition
- The test was sufficiently simple to be used by producers

- Water Quality and Herbicide Efficacy
- Glyphosate is sensitive to water quality
- Water treatment with coagulation significantly improved glyphosate performance at two of four sites in 1999.
- Coagulation will minimize screen and nozzle blockage by removing all large particles and dissolved metals such as iron from water.

- Unlined Coagulation Cells
- Unlined coagulation cells maintained water quality similar to lined cells
- Unlined coagulation cells allow rodents and pets to climb out of the cell
- Unlined cells have the distinct disadvantage of losing treated water to seepage

Improving Cold Water Coagulation with Polymers and Coagulant Aids

- Polyaluminum chloride and ferric chloride perform better than aluminum sulphate in cold water

- Treated water turbidity, particle counts and total suspended particles are affected by cold water coagulation using aluminum sulphate. DOC and colour removal are not affected.
- Polymers do not significantly improve cold water coagulation treatment

- Performance Monitoring of the Floc System 100
- The commercial coagulation system tested performs similar to the standard jar test
- The system was shown to remove up to 65 percent of dissolved organic carbon, up to 85 percent of colour and up to 95 percent of turbidity.
- The system has applications for both domestic and agri-food sector applications

- Review of Coagulation Research
- The coagulation process is an appropriate technology for use in the agri-food sector
- The process is unlikely to be marketable
- Research is needed to refine the mixing process

- Cattle Weight Gain Study
- Improvement in water quality by aeration and coagulation significantly increased cattle weight gain in one year of the three year study. The other two years showed not significant difference in weight gain between the water treatments.
- Consumption of water increased with improvement in water quality.
- Remote watering systems significantly reduced the e. coli and chlorophyll *a* level

- Coagulation Cell Liner Modification
- 30 mil polyethylene has a longer life than the 15 mil reinforced polyethylene and is about 25 percent more costly
- The slippery liner slope results in pets and rodents sliding down the slopes and being unable to climb out of the cell
- Covering the fold at the corners prevents rodents from chewing through the liner

- Sulphate Removal from Water
- Sulphate removal using absorption on bentonite clay was unsuccessful
- Ion exchange and nanofiltration are effective in sulphate removal

- Hog Weight Gain
- 4 different water "treatments" made no difference to the weight gain of the weanling pigs.
- Results were evident was evident after ½ of the planned trials and therefore

additional runs were viewed as superfluous.

- Reduced mortality rates were suggested by the coagulated water trial data. If repeatable, this could translate into $40,000 per barn pyramid.
- The mechanism for reduced mortality is suspected to be reduced pathogen loading in the coagulated water, and subsequently more effective disinfection..
- Study uncovered deficiencies in the knowledge and implementation of disinfection practices in the hog industry. Final reporting will include a sub report on this finding and provide recommendations.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Coagulation and Coagulation Cells
- Coagulation model at 12 trade shows and field days including Agribition and Farm Progress shows (4000 visitors)
- Demonstration of lined coagulation cell to 1000 producers at Western Beef Development Centre
- Demonstration of coagulation process to 200 producers
- Paper presentation at North American Lake Management Conference and Western Canada Water and Wastewater Association Conference.
- Featured on Prairie Farm Report

- Produced fact sheets:
- ***On-Farm Coagulation***
www.agr.gc.ca/pfra/water/facts/onfarm.pdf
- ***How to Coagulate your Dugout or Cell***
www.agr.gc.ca/pfra/water/facts/coaghow.pdf
- ***Chemicals for On-farm Coagulation***
www.agr.gc.ca/pfra/water/facts/coagchem.pdf
- ***Coagulation Beaker Test***

- developed Macromedia Flash animation as a simple visual explanation of the treatment process "***Coagulation Improves Water Quality***", used in training, demos and posted on the Internet:
www.agr.gc.ca/pfra/water/flash/coaglate.htm

- Numerous articles in newspapers

- Mixing
- Paper presentation at ASAE-CSAE conference

- Algae Effects on Coagulation
- Paper presentation at the 36th Central Canadian Symposium on Water Pollution Research
- Paper to be published in the Water Quality Journal of Canada in 2002

- Water Quality and Herbicide Efficacy
- Field day at Scott Research farm
  400 producers attended
- Two field days at CSIDC
  400 producers and government employees attended
- Poster presentation at two conferences
- Oral presentation at Farm Tech 2000 (50 producers)
- Produced project information sheet ***Impact of Water Quality on Herbicide Efficacy***
- Featured television report on "**Prairie Farm Report**"
- Field day at commercial applicators water source (30 producers)
- Numerous articles in daily and weekly newspapers

- Improving Cold Water Coagulation with Polymers and Coagulant Aids
- Paper presentation at the 35th Central Canadian Symposium on Water Pollution Research
- Paper published in the **Water Quality Journal of Canada in 2001**
- Abstract accepted for the 2002 CSCE Environmental Engineering Conference

- Performance Monitoring of the Floc System 100
- Paper presented at the **2001 NSF Conference on Small Drinking Water and Wastewater Systems**
- Produced fact sheet:
  Commercial Coagulation Systems
  http://www.agr.gc.ca/pfra/water/facts/inhousec.pdf

- Cattle Weight Gain Study
- WBDC summer field days (900 producers)
- WBDC winter field day (80 producers)
- Produced fact sheet ***Water Quality and Cattle***
- Produced project information sheet ***Livestock and Water Quality***
- Presentations at two conferences
- Presentation to 70 producers in Moose Jaw Workshop
- Presentation to 200 producers in a Saskatoon Workshop
- Presentation to 30 producers in a Ducks Unlimited Workshop
- Featured television report on "**Prairie Farm Report**"
- Numerous articles in magazines, daily and weekly newspapers

- Sulphate Removal from Water
- Paper presentation at the **36th Central Canadian Symposium on Water Pollution Research**
- Paper to be published in the **Water Quality Journal of Canada in 2002**

- Hog Weight Gain
- Focus on the Future Conference 2002 "Optimizing the Production System" Feb 19 and 20, 2002, Winnipeg MB Canada.
- Two papers published:
- ***Water Quality and Nursery Pig Performance: How Important is It?***
- ***Impact of Water Source (Ground versus Surface) and Treatment on Nursery Pig Performance***

COLLABORATORS AND OTHER CONTRIBUTIONS:

- over ten producers; a commercial crop sprayer
- Canada-Saskatchewan Irrigation Diversification Centre
- University of Saskatchewan
- Agriculture and Agri-Food Canada Research Branch
- Saskatchewan Wheat Pool
- Aventis Crop Science
- WateResearch Corp.
- Western Beef Development Centre
- University of Regina
- Tec-Water Supplies Inc.
- University of Alberta
- Nilex
- Kelln Solar
- Ducks Unlimited
- Rural Water Development Program
- Prairie Swine Centre Inc.
- University of Manitoba
- Elite Swine Inc.
- Triad Nurseries
- Manitoba Water Services Board
- Manitoba Agriculture
- In-kind PFRA support
- Combined In-kind and External Contributions total over $700,000

2.4 AERATION (Project 250622; File: 6672-1-12-1-5)

PURPOSE:

- optimize the design of aeration systems to maintain and enhance water quality in dugouts and small reservoirs to improve source water quality, and to reduce the need for expensive point-of-use treatment systems

DETAILS:

- Evaluated electrical and wind aeration, effects of geography on aeration, and large dugout aeration needs.
- Conducted long-term effects of aeration with W.C. Mackay & Associates.
- Developed a solar aeration system option for remote dugouts.
- Reports:
  - **Effects of Dugout Aeration on Winter Quality 96/97**
  - **Effects of Long Term Aeration on Summer Water Quality 97/98**
  - **Effects of Long Term Aeration on Summer Water Quality 98/99**
  - **Effects of Geography on the Quality of Dugouts in Response to Continuous Aeration 1999**
  - **Effects of Geography on the Quality of Dugouts in Response to Continuous Aeration 2000**
  - **Dugout Aeration Weyburn 1999**
  - **Dugout Aeration, Weyburn 2000**
  - **Dugout Aeration, Gravelbourg 1999**
  - **Dugout Aeration, Gravelbourg 2000**
  - **Microcystin - LR Levels in Water Supplies 97/98**
  - **Microcystin - LR Levels in Water Supplies 1999**
  - **Optimizing the Design of Aeration systems in dugouts**

KEY FINDINGS:

- Continuous year-round diffused aeration is a simple and effective way to keep stagnant farm pond water (dugout water) fresher and better quality.
- Aeration works by keeping water circulated, and minimizing nutrient re-cycling from the bottom sediment.
- Several design approaches are possible to suit the type, size and location of pond.
- Continuous long term aeration of dugouts result in an improvement in water quality.
- The best aeration results are achieved when air is delivered through an efficient diffuser located at the bottom (i.e. the deepest part) of the dugout.
- Effective aeration circulates the whole body of water and keeps the surface of the mud sediment at the bottom of the dugout oxidized and prevents the release of nutrients and other undesirable substances from the bottom sediment into the water column.
- Water clarity, water colour, total phosphorus, soluble reactive phosphorus and chlorophyll *a* were all significantly reduced by continuous aeration.
- Other parameters measured, nitrate plus nitrite, ammonia and turbidity were reduced by aeration but the difference between continuously aerated and controls were not great.

- Results obtained in southern Saskatchewan are not comparable to the results obtained in the Peace River district of Alberta, indicating that geographical and environmental differences impact the effectiveness of aeration.
- Data showed that nutrient levels in southern Saskatchewan dugouts where much higher than those measured in the Peace River district of Alberta and would need higher level of diffused air and circulation to maintain maximum dissolved oxygen levels.
- Best management practices (BMP's) also play a major part in improving water quality. Poor water quality in many of the dugouts studied in southern Saskatchewan appears to be the result of external input of relatively high levels of nutrients on a regular basis. Dugouts in southern Saskatchewan did not use BMP's to control input to their dugouts as was used in Peace River district of Alberta.
- The wind powered aeration/mixing devices tested were able to maintain minimum levels of dissolved in the deepest water during July and August when controls became anoxic at the bottom.
- Continuous long term aeration of dugouts result in reduced levels of cyanobacteria to very low levels, but increases green algae.
- Intermittent aeration reduced both cyanobacteria and green algae.
- No correlation could be found with any variables measured with the production of microcystin - LR in aerated and unaerated dugouts.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- AWWA conference Saskatoon, paper
- CWRA conference Guelph, poster
- NALMS conference Madison, poster
- ASAE-CSAE conference Red Deer, presentation
- Agribition Regina, demo and display of aeration technology (four years)
- Farm Progress Show Regina, demo and display aeration technology (three years)
- Numerous presentations to farm and RM groups
- Fact sheets:

Published 5,000 copies each and posted on: www.agr.gc.ca/pfra/water/wqualite.htm

- ***Why Aerate Your Dugout***
- ***How to Aerate Your Dugout***
- ***Myths About Dugout Aeration***
- ***Basic Electric Aeration Details***
- ***Solar Powered Dugout Aeration***

Published eight technical aeration design sheets (5,000 copies), and posted on the Internet at www.agr.gc.ca/pfra/water/wqualite.htm:

- ***Standard PFRA Assembly for Small Single Diaphragm Aeration Compressors (Drwg. 265019)***
- ***Standard PFRA Assembly for Small Dual Diaphragm Aeration Compressors (Drwg. 265020)***
- ***Standard PFRA Assembly for Koenders EL2 Aeration Compressors (Drwg. 265021)***
- ***Standard Aeration Installation Components (Without Condensation Tanks) (Drwg. 265022)***

- ***Standard Aeration Diffuser Connection Details - 1 (Drwg. 265024)***
- ***Standard Aeration Diffuser Connection Details - 2 (Drwg. 265025)***
- ***Standard Condensation Tank Construction Details (Drwg. 265026)***
- ***Bleeder Device Options for PFRA Standard Aeration Compressor Assemblies (Drwg. 265023)***
- Macromedia Flash animated presentation
  Dugout Aeration Improves Water Quality
  http://www.agr.gc.ca/pfra/water/flash/dugout.htm
- Produced table-top aeration models for use at workshops and trade shows, and manufactured aeration trailers for demonstrations at field days
- Articles appeared in Regina Sun, Leader Post and Manitoba Agri-Times.

COLLABORATORS AND OTHER CONTRIBUTIONS:

- 40 producers across Saskatchewan
- University of Alberta
- University of Regina
- Kelln Solar
- Western Beef Development Centre
- In-kind and External Contributions total over $100,000

2.5 WELL REMEDIATION (Project 250623: File: 6672-1-12-1-6)

PURPOSE:

- advance innovative well remediation technology using the Ultra Acid Based well treatment technique; this technology will be evaluated as a potentially commercially viable system for improving the quality of water in wells with biological deterioration

DETAILS:

- Worked with Droycon Bioconcepts Inc. to evaluate Ultra Acid Based Well Treatment processes on the treatment of a well to supply the City of North Battleford.
- Conducted a research study with University of Regina to investigate nitrate treatment processes for waters that have high levels of nitrate. Processes investigated included biological sulfur/limestone autotrophic denitrification, ion exchange and reverse osmosis. This research will lead to a better understanding of processes that may help treat water supplies high in nitrate concentrations.

KEY FINDINGS:

- Regular well maintenance is critical for most wells, and especially critical when biological fouling is rapid.
- Many wells are susceptible to biological fouling. BART tests (Biological Activity Reaction Tests)) are useful techniques to help identify the biological fouling potential of ground water.
- Remediation by any method, including UAB treatment, may not be enough to recover a severely biofouled well.
- Removal of nitrate contamination from water is possible with sulphur/limestone autotrophic denitrification (SLAD) process. The SLAD process is likely more economical than ion exchange or reverse osmosis processes.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Submitted articles on preventive well maintenance to various publications.
- Presented and published "***Nitrate Removal from Potable Water***",a paper on nitrate water treatment in "Proceedings of the 9th National Conference on Drinking Water", Canada's National Drinking Water Conference held in Regina, May, 2000.
- Reports:
- **City of North Battleford Well Rehabilitation Project - Summary Report**
- **City of North Battleford Well Rehabilitation Project - Appendices**
- **Nitrate Removal from Potable Water**

COLLABORATORS AND OTHER CONTRIBUTIONS:

- City of North Battleford
- RM of Dufferin
- producers

- University of Regina
- In-kind and External Contributions total over $300,000

PART 3: WATER QUALITY PROTECTION

3.1 ECONOMIC VALUE (Project 250624; File: 6672-1-12-1-7)

PURPOSE:

- determine the economic value of protecting water quality versus remediation
- document the cost of water infrastructure to determine the value of developing appropriate water sources (including treatment) for rural water needs (e.g. agri-food sector, livestock watering, domestic, etc.)

DETAILS:

- Hired an economic consultant, Dale Russell to undertake an economic analysis on protecting and treatment of water supples.

KEY FINDINGS:

- It makes economic sense to protect water supplies from contamination.
- Good quality household water is more costly to rural households than urban households.
- Improved water quality can provide economic benefits to producers.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Report: **Economic Aspects of Rural Water Quality**

3.2 BEST MANAGEMENT PRACTICES (Project 250625: File: 6672-1-12-1-8)

PURPOSE:

- Determine, evaluate and promote agricultural Best Management Practices (BMP's) which are effective in Saskatchewan for protecting water quality.

DETAILS:

- Reports:
  - **Agricultural *Best Management Practices* for the Canadian Prairie**
  - **Tillage Systems and Surface Water Quality and Quantity**
  - **Protecting Sensitive Ecosystems from Pesticide Drift**
  - **Agrochemical leaching Under Intensively Irrigated Crop Production**
  - **Agricultural Practices and Water Quality in Saskatchewan: The Social Ecology of Resource Management**
  - **The Sociology of Agricultural Practices and Water Quality: An Annotated Bibliography**

KEY FINDINGS:

- Conclusions have been drawn about the anticipated effectiveness of different practices in the Canadian context. The conclusions discuss the following practices:
  - Conservation Tillage - high benefits with moderate costs
  - Grassed Waterways - high benefits with moderate costs
  - Remote Watering of Livestock - high benefits with moderate costs
  - Nutrient Management, high input crops - high benefits with moderate costs
  - Vegetated Buffers adjacent to water bodies - high benefits with moderate costs
  - Shelterbelts - high benefits with high costs
  - Constructed Wetlands - high benefits with high costs
  - Storage, Handling of Fertilizers and Pesticides - moderate benefits with low cost
  - Crop Rotations - moderate benefits with low costs
  - Pasture Management - moderate benefits with moderate costs
  - Riparian Area Management - moderate benefits with moderate costs
  - Integrated Pest Management - low benefits with moderate costs
  - Nutrient Management, low input crops - low benefits with moderate costs
  - Vegetated Field Edge Filter Strips - low benefits with high costs
- Livestock producers are showing a keen interest in adopting alternate livestock watering methods to protect water supplies and preserve animal health.
- Larger droplet chemical spray nozzles have lower pesticide spray drift; these are being adopted more and more by commercial sprayers.
- Surface runoff is lower on zero till systems after the initial years.
- High concentrations of nitrate occur when high rates of nitrogen fertilizer are applied to irrigated potatoes.

- Producers know that farming practices affect water quality. However, without reliable data, it is not possible for producers to know the environmental benefits of adopting Best Management Practices.
- Tillage Systems:
- A number of water quality models were reviewed in relation to different tillage systems data collected at a Saskatchewan site. The Agricultural Non-Point Source pollution model (AGNPS) and the Cold Regions Hydrology Model (CRHM, under development at Environment Canada's National Water Research Institute), were chosen for further evaluation. CRHM showed more promise in simulating snowmelt runoff and a land surface scheme and water quality module were developed for the model. The goal is to obtain a better understanding of different tillage systems and water quality. The tillage systems studied were: long-term zero till, shorter-term zero till, conventional tillage with high inputs, conventional tillage with low inputs.

- Pesticide Drift:
- Low drift sprays reduced fallout by 75% in the absence of vegetated buffers and 83-99% when a buffer was present
- Grass buffer reduced fallout by 24 and 44% for conventional nozzles and conventional nozzles respectively
- Low bushes reduced fallout by 95%
- Trees reduced fallout by 82 and 97% for conventional and low drift nozzles respectively
- Conclusions indicate that risk of contamination of water bodies by airborne pesticide spray drift may be significantly reduced by maintaining vegetated riparian zones and using low-drift spray technology.

- Irrigation and Fertilizer Management of Potatoes:
- In each year under potatoes, the water table rose, whereas it fell under wheat and canola. This is attributed to the inefficiency of potatoes rather than over-irrigation.
- Under potatoes, nitrate levels in shallow groundwater increased under the highest fertilizer rate, fertigation and the split N application. Increases in NO_3 concentration in shallow groundwater were consistent with downward leaching of N.
- Pesticides detected in groundwater samples under the three-year rotation of potato, canola and wheat, tended to be present in the year they were applied and the year following application. Concentrations generally tended to be at trace levels.

- Social Ecology:
- A variety of economic, institutional, organizational and social factors interact to influence farmer's decisions about resource management.
- Institutional efforts to encourage farmers to voluntarily accept BMPs are likely to fail.

- Initiatives to support production and productivity in the agricultural sector may be required to promote protection of water quality.

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Fact Sheets published (5,000 hard copies each), and posted on the Internet at www.agr.gc.ca/pfra/water/wqualite.htm:
  - ***Agricultural Best Management Practices***
  - ***Alternatives to Direct Access Livestock Watering***
  - ***Pest Management and Water Quality***
  - ***Nutrient Management and Water Quality***
  - ***Riparian Area Management***
  - ***Soil Texture and Water Quality***
  - ***Winter Watering for Livestock***
  - ***Muskrat Control in Farm Dugouts***
- Developed Macromedia Flash animation, depicting Best Management Practices. This is a unique presentation geared to the young and old, using humour in its design of showing how BMPs can be adopted to protect water supplies. The ***Best Management Practices Animation*** uses Robocow, as a superhero solving problems with BMPs. It is posted on the Internet:

www.agr.gc.ca/pfra/water/flash/robocowe.htm

- Edited and contributed material and recommendations for **Quality Farm Dugouts**, a federal-provincial manual on how to build, operate and maintain farm dugouts (ponds).
- Remote summer watering technologies field demo site, visited by over 500 people
- Winter-watering technologies field demo at Western Beef Development Centre, visited by over 500 people.
- Winter-watering for livestock field demo at producer site, showcases two types of solar powered systems; site used for field tours
- Dugout management in a cropped watershed for field demo; showcases inlet control, grassed waterways, solar powered livestock watering
- Dugout management for livestock watering; showcases runoff by-pass, inlet control and remote watering
- Results from the Social Ecology of Resource Management were presented to a national meeting of the Canadian Water Resources Association in Guelph, and were posted at an international Internet workshop sponsored by the Food and Agriculture Organization (FAO).

COLLABORATORS AND OTHER CONTRIBUTIONS:

- two producers
- Environment Canada - National Water Research Institute
- Agriculture and Agri-Food Canada - Research Branch
- Health Canada - Pest Management Regulatory Agency
- Canada-Saskatchewan Irrigation Diversification Centre
- Genesis Land Conservancy
- Western Beef Development Centre
- In-kind and External Contributions total over $300,000

3.3 WATER QUALITY PROTECTION IN WELLS (Project 250626: File: 6672-1-12-1-9)

PURPOSE:

- determine cost-effective techniques for protection of water quality in wells and aquifers

DETAILS:

- Wrote a manual on well abandonment and reclamation.
- Wrote a fact sheet on approaches to seal abandoned wells.
- Initiated surveys to determine extent of unsealed well problems in rural Saskatchewan.
- Partnered with SaskWater and Saskatchewan Ground Water Association on defining acceptable practices to seal abandoned wells

COMMUNICATION AND TECH TRANSFER ACTIVITIES:

- Worked with a communications consultant to produce a well abandonment manual and fact sheets (task not yet completed).
- Worked at trade shows and workshops to advocate the importance of well protection.
- Well abandonment field day held near Wadena, SK
- Developed a large scale model illustrating fundamental concepts involved in sealing large diameter wells.
- Gathered information from the Sixth Canadian-American Conference on Hydrogeology sponsored by the National Ground Water Association in Banff Alberta on July 9/10, 2001.
- Presented posters and well model demonstrations at trade shows and workshops.

KEY FINDINGS:

- Many rural residents not aware of extent of unsealed well problem in their "own backyard".
- Many Saskatchewan rural municipalities may have hundreds of unsealed wells.
- There is possibly a link between poorly sealed wells and short-lived replacement wells.
- There is significant resistance to sealing "backup" wells even though few are ever used.
- There is a need for future programming related to sealing unused wells.

COLLABORATORS AND OTHER CONTRIBUTIONS:

- Saskatchewan Ground Water Association
- In-kind and External Contributions total about $50,000

PART 4: **TECH TRANSFER** (Project 250627; File: 6672-1-12-1-10)

PURPOSE:

- ensure that the agri-food sector and rural residents understand the importance and value of adequate quality water for specific and particular uses
- ensure that the techniques and technologies developed under Parts 2 and 3 of the work plan are effectively transferred to their target audiences

DETAILS:

- Worked with Polmac Communications Inc., a communications consultant, to prepare a Tech Transfer and Communications strategy.
- Report: **Rural Water Quality Program Technology Transfer Plan**

- Field Days and Trade Shows:

Western Beef Development Centre

- Field days held in 1999, 2000 and 2001 summer and fall
- Approximately 300 producers each field day
- Projects featured coagulation treatment, cattle weight gain study, remote livestock watering, aeration, biological water filtration, Best Management Practices
- Presentations, tours, and education and awareness of water quality

Farm Progress Show

- Large three day trade show held in Regina each year, with 50,000 attendees
- Featured projects in 2000 and 2001
- Themes included protection and BMPs, well protection and remediation, coagulation, aeration, biological filtration, membrane filtration, cattle weight gain
- provided fact sheets, information sheets and personal contact and water quality extension advice, as well as featured speaker at one of the information sessions
- Booth attendance is estimated to be about 2,000 each year

Agribition

- Major Canadian agricultural trade show with 150,000 attendees each year
- Featured AFIF water quality research projects in 1998, 1999, 2000, 2001
- Themes included Best Management Practices, Alternatives for Remote Livestock Watering, Well Protection, Surface Water Protection, Well Remediation, Biological Filtration, Membrane Filtration, Aeration
- Key elements included models, Macromedia Flash presentations, displays, photos and posters of technologies, hands-on technology information sessions, providing fact sheets, extension assistance
- Estimated booth attendance over the 7 days: about 5,000 visitors each year of 4 years for a total exposure of about 20,000 people

Shelterbelt Centre 100th Anniversary Field Day

- July 2001 at Indian Head attended by over 1000 people
- Themes were aeration, biological water treatment, membrane filtration, disinfection
- Aeration models, ground water demonstration trailer, water quality displays and posters
- Over 200 people toured the trailer

Vanguard Field Day

- Held at a producer's farm near Vanguard
- Attended by 50 producers and government extension
- Focus was protection of wells, well management and maintenance, aeration of dugouts, coagulation, biological water treatment, membrane water treatment, monitoring and testing water
- presentations, displays, models, tours and water quality demo trailer tours

Moose Jaw Water Quality Workshop

- Over 75 producers attended a full-day workshop on water quality
- Featured information on protection of water supplies, aeration of dugouts, water treatment using coagulation, biological filtration, membranes, water quality impacts on livestock, alternate livestock watering devices.
- Presentation, models, and displays were utilized.

Sask Ag and Food Workshops

- Over 80 government extension personnel (one workshop in Saskatoon, one in Kenosee)
- Presentations and break-out sessions were held
- research was highlighted

Canada-Saskatchewan Irrigation Diversification Centre Field Days

- Over 300 attendees in two consecutive years
- highlighted protection technologies, alternate livestock watering, well protection and maintenance, biological water treatment, membrane filtration

Coteau Hills Rural Water Pipeline Association Water Treatment Clinic

- Attended by over 42 producers
- Training was provided in operation and maintenance of in-house water treatment devices, emphasising watershed protection, BMPs and effective treatment.

Seagher Wheeler Field Day

- Attended by over 300 people with over 50 touring the water treatment trailer
- Focus was biological treatment, coagulation, membrane filtration, and

effective operation and maintenance, water testing

- covered in The Western Producer

AAFC Melfort Research Station Field Day

- Attended by 125 people with 10 touring the water treatment trailer
- Focus was biological treatment, coagulation, membrane filtration, and effective operation and maintenance, water testing

AAFC Scott Research Farm Field Day

- Attended by 240 people with about 30 people touring the water quality treatment trailer to learn about biological filtration, membrane treatment, coagulation
- Previous year: about 200 attended with about 50 touring display and tech transfer for information regarding water quality impacts on herbicides and coagulation treatment as an option to pre-treat water

Saskatoon Fall Fair

- Attended by 5,000 adults and over 1300 school children touring, with over 230 visiting the water quality booth
- Theme was Livestock and Water Quality
- Demos on aeration, and posters on alternate livestock watering devices
- Information on copper sulphate treatment for dugouts

Cattle Congress, Saskatoon

- Attended by 4,000 people with over 250 visiting the water quality booth
- Theme was Livestock and Water Quality
- Demos on aeration, and posters on alternate livestock watering devices
- Information on copper sulphate treatment for dugouts

- Presentations highlighting AFIF-researched water quality protection and treatment technologies:
  - Saskatchewan Poultry Industry Conference, Saskatoon
  - Centre for Rural Studies and Enrichment Canadian Rural Revitalization National Conference, Muenster
  - CropLife Canada-Saskatchewan Council Conference, Saskatoon
  - Vision for the Future Saskatchewan Conservation & Development Conference, Saskatoon
  - Pork Central workshops training pork producers
  - Dalhousie University's "Water Quality Issues and Treatment Options" Continuing Education course sponsored by CSCE in Regina
  - Key Foundation, Regina. An overview of water quality and AFIF technologies was presented to over 30 teachers from across Canada at the Society and the Environment Summer Conference on Sustainable Agriculture and Sustainable Forestry
- Fact Sheets:

- ***Water Quality Testing***
- ***Aluminum and Health***
- ***Algae and Cyanobacteria***
- ***Copper Treatments for Dugouts***

The AFIF Rural Water Quality Project has published over 300,000 copies of approximately 30 fact sheets, the majority having been written and developed directly from work conducted under this project. These are also posted on PFRA's Internet site: www.agr.gc.ca/pfra/water/wqualite.htm .

- Publications:
- **Innovative Technologies and Tech Transfer for Rural Water Quality Needs** in the Third NSF International Symposium and Technology Expo on Small Drinking Water and Wastewater Systems: Treatment, Management and Finance, April 22-25, 2001, Washington
- **On-Farm Strategies to Improve Water Quality** in ASAE-CSAE/SCGR Pacific Northwest 56th Regional Conference, Red Deer
- **Water is Life, Agriculture in the Classroom 2001 Study Series Special Edition**. Presentations and sponsorship to this special publication was provided. The focus of this publication is water and agriculture. Copies of the publication were distributed to every school in Saskatchewan, and posted on the Internet. The materials include teaching activities appropriate for Kindergarten to Grade 12.

- **Field of Streams Science Centre Permanent Interactive Display**
- Unveiled in October, 2001
- This is an interactive display featuring the need to protect water supplies by adopting effective land use practices. Children will be able to construct and re-construct different farm layouts near flowing water and ground water systems. The display will be used in presentations to educate children how land use can impact water or protect water supplies.

- **Training Modules**; Water quality knowledge was advanced by the AFIF Rural Water Quatity Program. PFRA personnel recognized a need to educate more government extension staff, and initiated the development of nine training modules. The modules are approximately 80% completed and are expected to be finished in the year following completion of the AFIF program. The topics are:
- **Watershed Management**: This module teaches student the importance of watershed management in order to protect surface and ground water supplies. It will include a manual for stakeholders, written by Water Quality Unit, and several popular publications.
- **Water Treatment Processes** will teach students the fundamentals of multiple barrier water treatment to deliver small-scale needs for good quality water for the agri-food sector, from source to tap.
- **Livestock Watering** will include detailed training on how to utilize different types of livestock watering devices for summer or winter application,

powered by electricity, wind, solar or animal nozzles.

- **Technology Transfer** is a module intended to train PFRA personnel and scientists in the broad range of necessary techniques to get science and knowledge to the agri-food sector, in ways and methods that speak to the audience, with the goal striving to be the learning and adoption of new knowledge and technology.
- **Livestock Runoff Treatment Systems** will present options on how to deal with nutrient-rich and pathogen-rich runoff from livestock facilities. The module will focus on biological, physical and chemical ways to minimize impacts of livestock manure on water supplies. Eco-technologies will be one of the treatment methods presented (e.g. wetlands).
- **Water Quality Sampling** will teach students on correct methods to obtain, collect and preserve water samples for monitoring or research programs.
- **Water Well Management** will include methods of proper well siting, construction, operation and maintenance, and well abandonment, to protect aquifers from contamination, and to preserve optimum water quality at the well.
- **Nutrient Management** will teach students method to manage agricultural nutrients (manure, fertilizer), to ensure the protection of water supplies.
- **How to Conduct Applied Research & Development** will teach PFRA personnel the key features of conducting applied research, and how to use their field expertise jointly with research scientists in an effort to conduct field research and/or pass new knowledge and technologies (i.e. science) to the benefit of the agri-food sector.

KEY FINDINGS:

- There is an increasing interest by the rural and urban public, and the media regarding water quality issues, concerns and linkages to agriculture.
- Canadians want assurance that water supplies are protected.
- Agriculture depends on good quality water and requires sound advice and information on water protection and treatment. The sector views government as a credible source for this information. The sector and rural people often do not have access to good quality water, nor access to good information on how to obtain the best possible water quality for domestic and agricultural needs.
- Improved education and awareness on the need to protect water supplies, and ways to treat poor quality rural water is necessary for rural Canadians and the agri-food sector in general.
- A variety of public education methods is necessary (fact sheets, web-based interactive materials, models, trade shows, presentations, scientific papers, etc.)
- There is a better desire for collaboration between federal and provincial agencies who are now showing more interest in water quality following contamination events in Walkerton Ontario and North Battleford Saskatchewan.
- There continues to be an increased need for government involvement by agencies working together to help rural Canadians and the agricultural sector with water quality protection and treatment needs.

COLLABORATORS AND OTHER CONTRIBUTIONS:

- Media coverage was provided by:
- CTV and CFQC television
- CTV's Farm Gate
- CTV's Prairie Farm Report
- Global television
- CBC National and local Radio
- numerous provincial radio news media, across Saskatchewan (Yorkton, Swift Current, Regina, Saskatoon, etc.)
- The Western Producer
- Maclean's national magazine
- The Star Phoenix
- The Leader Post
- Saskatchewan Agriculture and Food Extension Branch, for distribution of fact sheets, holding workshops, etc.
- SaskWater meetings and workshops
- In-kind and External Contributions for Technology Transfer total an estimated $200,000 to $300,000